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upper Edge of the shade Vane, to the Sun, and it will give what is required: The same Rule is to be observed in taking the Altitude of a Star.

II. *The Description and Use of an Apparatus added as an Improvement to Davis's Quadrant, consisting of a Mercurial Level, for taking the Co-altitude of Sun or Star at Sea, without the usual Assistance of the sensible Horizon, which frequently is obscured.* By Charles Leigh, Gent.

I Had the Honour some time ago, [Nov. 3. 1737.] to communicate to this learned Society, an Invention much upon the same Nature and Principle with this; since which I have made such Alterations and Improvements thereto, as have render'd it complete and perfect for the Use intended, and have been confirmed by repeated Experiments, as well on board Ships, as on Shore. An Instrument of this Nature we greatly want at Sea, and it would be a great Satisfaction to me, if any Thoughts and Inventions of mine should contribute to the removing of this grand Impediment, that so frequently happens.

To arrive to the utmost Perfection in Navigation, three things are absolutely requisite, *viz.* The Variation, the Latitude, and the Longitude; which last is, as yet, conceal'd from us. The two former indeed,

we have a tolerable Certainty of, especially the first, which may be found by Observation, almost at any time the Sun shall be visible in or above the Horizon, either by an Amplitude or Azimuth; but unhappily as yet, it is not so in regard to the Latitude, by any certain Method, but what is looked on as too abstruse for common Practice; for it is but *once* in 24 Hours that an Observation can be made from the Sun, and even that Space of Time so very short, that if the Horizon should then be obscured, or a Cloud intercept the Rays of the Sun, the dead Reckoning is then the only Guide, which, in Fact, is little better than groping in the Dark.

Since the Latitude then is our principal Guide at present, and liable to these Obstructions, it would be unnecessary to inlarge on the Advantages that would accrue to Navigation from Improvements tending to obviate them. As this Invention removes a very material Obstacle, *viz.* an obscure Horizon, there remains another, which, I hope and believe, is not altogether impracticable to remove; and that is, being confined but to one short Space of Time for Observation, as already mention'd; and doubtless it would be of great Advantage to Navigation, could an accurate Method be found for discovering the Latitude as frequently in the Day, as you may that of the Variation.

But to return to the Instrument under Consideration, which is founded on this obvious Principle, *viz.*
 “ That the Surfaces of all Liquids, that have a Com-
 “ munication with each other, though separated at
 “ any Distance in their Surfaces, will be in a true
 “ horizontal Plane.”

The first Instrument that I made conformable to this Principle, was with a Water-Level; but finding that Water was subject to some Inconveniencies, I altered the Apparatus, and changed the Fluid from Water to Mercury: This Alteration and Improvement will more intelligibly appear by the Instrument, and also the Draught hereunto subjoined, TAB. I. Fig. 1. where *AB*, *CD*, represents the Segments of two different Circles that are concentrick; *E*, the common Centre, in which moves the Pin or Axis fitted to the Index or Label *EF*; on which Label is also fix'd the horizontal Tube *Gg*, which has a Communication with the two glass vertical Tubes *Eh*, *dh*, in which moves the Mercury. On each Top of the vertical Tubes are fix'd a large hollow brass Cylinder *hh*, having in their Tops a Pin, by closing of which, the included Air is prevented from any Communication with the External; by which means this Advantage is obtained, that it prevents, in a great measure, that too quick and vibratory Motion that is natural to the Fluidity join'd to the Gravity of Mercury when moved, and at the same time, by having a sufficient Space and Quantity of Air in the Cylinders at Top, does not in the least impede the true Level; but notwithstanding this Precaution, the Mercury still would be subject to a tremulous Motion, were it not that the Diameters of the vertical Tubes, to that of the horizontal, are as 2 to 1, and consequently the Area 4 to 1; by which means this Inconveniency is also removed, without any way affecting the horizontal Level.

The first trimming or preparing the Tubes with Mercury is sufficient, and when the two little convex Surfaces of the Mercury appear just visible above the level

level Rings *Ee*, then is the Instrument correctly trimm'd; if they appear much above or below the Rings, move the Tubes a little up or down, till the Surfaces are adjusted to the Rings; which is effected by means of the regulating Screw *l*, fix'd at the End of the Base Tube.

As I well know the Fondness our Navigators have to *Davis's* Quadrant, I adapted the Apparatus to this Instrument, which is so far from being perplexing, that it becomes obvious at first View, and by which an Observation can be made with great Facility; for the Observer may place himself in the most convenient Part of the Ship, where there is the least Motion and Wind to disturb him, and sitting on a Stool or the Deck, holding the Instrument with his left Hand under the horizon Vane *Ez*, and his Right at the End of the Label *F*, with his Thumb thereon, keeping the Label on the same Height or Level with his Eye, bring the left convex Surface of the Mercury to appear just visible above the central Ring *E*, and the Shade or *Speculum* of the Sun from the Solar Vane *k*, to coincide therewith on the central Line *Ez*; and the Sum of Degrees and Minutes cut on the two Arches by the Vane *k*, and the End of the Label *F*, will give, as usual, the Angle of the Sun's Co-altitude. As the Sun rises, the Shade will fall below the central Line (the Surface in its proper Place); and when it passes the Meridian, and falls, it will appear above, so that the End of the Label must be moved in the same manner as the Sight Vane usually is.

To observe by a Star, another Person must look through the Slit on the Horizon Vane, and over the upper Edge of the Shade Vane, and bring the Star to coincide

coincide therewith, proceeding in the same manner as before, with the Sun.

There are two very opposite Causes of an obscure Horizon; the one proceeds from thick hazy Weather, and the other from fine, clear and calm Weather, as I have often experienced at Sea: I have been running with a Fresh of Wind, sometimes five, six and seven Days together, the Distance of 2 or 300 Leagues, without an Observation; and on the sixth, seventh or eighth Day, it has proved stark calm and clear Weather, but the Sea so smooth, and so like in Colour to the Sky, that the Edge or Circle of the sensible Horizon could not be distinguished therefrom, and consequently no Observation to be made by the Instruments then in Practice.

By this Improvement to *Davis's* Quadrant, the above Obstacles are intirely removed; so that an Observation can be made off of Headlands, in Harbours, on Shore, and, in short, anywhere that a Sight of the Sun, &c. can be obtained, without any regard had to the Horizon; and, what is peculiar to it, is, that the true Level will be preserved, as well on the Top of the highest Mountain, as close to the Surface of the Horizon. The Apparatus is so contrived, that an Observation can be made with the sensible Horizon as usual, by means of the Sight Vane *N*, fixed near the End of the Label for that Purpose, so that the one will be a Proof to the other.

As the Success of Inventions in all things of this kind must be confirmed by Experiments only, among many others, two were effectually made on board his Majesty's Ship *the Oxford* at *Spithead*, in a high Wind,

when the Motion was short and quick, and consequently, a greater Disadvantage than if on the high Sea, where the Motion is grave, slow and regular, occasion'd by long Waves; but notwithstanding this quick Motion, the Observation made, exactly agreed with the Latitude of the Place; as will more evidently appear by the Report hereunto annex'd, signed by all the Principal Officers that were then on board.

THE new Improvement made by Mr. *Charles Leigh* to *Davis's* Quadrant, consisting of a Mercurial Level, for taking the Sun or Stars Altitude at Sea, when the sensible Horizon is obscur'd either by thick and hazy Weather, or in smooth Calms, when the Sky and Horizon are not distinguishable, was tried on board this Ship, when the Latitude by Observation made with the said Instrument agrees, as appears by the following Calculations; *viz.*

March the 9th, high Winds,
and a quick Motion.

March 10th, ditto
Weather.

Sun's Zenith Dist.	$50^{\circ} 30''$	} Zenith Distance	$50^{\circ} 38''$
Sun's Declination	15° S.		9° N.
Lat. by Observ.	$50^{\circ} 45'$	} Lat. by Observ.	$50^{\circ} 47'$

From which Experiment we judge this Instrument sufficiently accurate for discovering the Latitude, and removing that grand Impediment that fre-

frequently happens by an obscure Horizon, and consequently to be of great Use in Navigation.

*From on board his Majesty's
Ship Oxford, at Spithead,
March 10. 1738.*

Signed,

Thomas Strachey, first Lieutenant.

Thomas Griffin, Lieutenant.

James Irving, Master.

William Slanning, second Master.

*Note, The Latitude of Spithead the } ^o 50 ["] 46
nearest is about }
North.*

Directions concerning the Quadrant, &c.

THE Alteration made in this Instrument is greatly for the better, for the Level of Water requir'd to be trim'd every Time of Observation, besides the Hazard of spilling the Water from a great Motion; but in this Level of Mercury, the first Trimming serves always, and without hazard of spilling, being close confin'd, as will be seen in the Instrument.--- The Cylinders are made large enough to receive the Air that will be condens'd and rarefied alternately by the vibratory Motion of the Quicksilver through the small glass Tubes, without affecting the true Level Line, as will be found upon Trial: Notwithstanding, the

included Air has no Communication with the External, its being close confin'd gives this Advantage, that it prevents the Mercury, in its vibratory Motion, from being quick and tremulous.

The Bottoms of the brass Cylinder that the glass Tubes are fix'd in, must in the Inside be made Tunnel-wise, that the Mercury may not lodge behind. The Hole at the Top, and the Pin, is for taking out or putting in Mercury, if Occasion; as also to clean the Tubes with a Wire. The perpendicular Tubes must at least be twice the Diameter of the long Base Tube, for this Reason among others, that the dilating and condensing of the Mercury, from Heat or Cold, may not be sensible in the perpendicular Tubes; and also that the Base Tube must be as long as the Index or Label will admit, and the Tube thereof to be as small as can be, but so as to admit a Passage for the Mercury. This Passage should be through a small glass Tube inclosed in Wood, &c. The Cylinders must not be solder'd with soft Solder nor Silver: The Mercury will affect it.

Note, If the Mercury should be separated by an Air-bubble in the Tube, incline the Instrument till the Mercury disappears in the Tube below the Base, and it will take it out. The true Level is when the little convex Surfaces of the Mercury just appear above the Level Rings; then it is rightly trimm'd; and when you observe, you look only at one of them, *viz.* that at the Centre, the Shade Vane co-inciding at the same time on the Horizon Vane.

March II. 1738.

III. *A*